Chapter

Can Autonomous Vehicles Prevent Traffic Accidents?

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Abstract

Today, thousands of autonomous vehicles (AVs), also known as self-driving cars, are on roads. Besides, that number is anticipated to climb up, and AVs are expected to constitute 25% of cars worldwide in 2035. However, can AVs prevent traffic accidents? Results show that use of AVs will stay as a concern, and it will be hard to either champion or oppose them. From a positive perspective, AVs will contribute to traffic safety, increase economic and social benefits, and contribute to environmental protection. However, from a negative point of view, AVs would be hacked, expose our data to third parties, cause liability problems, increase carbon emissions into the atmosphere, risk our health, and constitute a financial burden in economies. The first section will introduce this chapter. The second section will give general information on the history AVs with a general description of them. How AVs work will be explained in the third section. The fourth section will mention the concerns regarding AVs. The pros, cons, and moral issues of AVs will be shown in the fifth section. The sixth chapter will argue the legal issues regarding AVs. Then, the seventh and final section will provide a conclusion.

Keywords: artificial intelligence (AI), autonomous vehicle (AV), self-driving car, computer vision, traffic accident, accident prevention

1. Introduction

Each year approximately 1.35 million people die as a result of traffic accidents that also cost most countries millions of dollars [1]. However, this unfortunate phenomenon mostly stems from humans. According to the US Department of Transportation's National Highway Traffic Safety Administration (NHTSA), 94% of the severe traffic accidents happen because of human errors [2].

Korean Road Traffic Authority defines the causes of traffic accidents as unsafe factors, unsafe road environments, insufficient driver knowledge, failure to recognize the danger, and improper thinking [3]. A study prepared by the NHTSA to be presented to the US Congress defines the causes of traffic accidents as driver-related, vehicle-related, roadway-related, and atmospheric condition-related factors [4].

Law firms approach problems from a different point of view since they aim to defend people at courts. As a result, they list the reasons for accidents in accordance with their legal bases. From the view of a law firm in the USA, causes of accidents are long listed as follows: distracted driving, speeding, drunk driving, reckless driving, rain, running red lights, running stop signs, teenage drivers, night driving, design defects, unsafe lane changes, wrong-way driving, improper turns, tailgating, driving under the influence of drugs, ice, snow, road rage, potholes, drowsy driving, tire blowouts, fog, deadly curves, animal crossings, and street racing [5].

Some may suggest that tire blowouts or unseen road signs are not human-related. However, while drunk driving or running red lights are explicitly related to drivers, a tire that is not changed in time or an unseen road sign that is not controlled by road authority employee is still implicitly associated with humans and human errors. Overall, it can be said that almost all accidents arise from the faults of humans, as suggested by NHTSA [2]. Nevertheless, are the humans aware that they are the main reasons for traffic accidents?

A recent study [6] researched the reasons behind the accidents by gathering data from the interview with police officers and drivers and traffic accident reports. Two of the main findings of the study are as follows:

- the reasons for accidents differ between the genders and across the age groups and

- when police officers and drivers are asked to assign the reasons for accidents, they only generated 25 possible causes; however, real accident reports included 63 accident causes [6].

The second finding mentioned above shows that the perceptions of people regarding accidents' causes are inadequate to understand the reasons and dynamics of accidents. Conversely, some factors such as uncorrected eyesight were listed by police officers and drivers; however, that did not take enough place in crash reports. While even police officers may have difficulty in identifying reasons behind accidents, how can we expect humans to take necessary actions to prevent traffic accidents? Or from another point of view, can AVs perform better than humans in driving? Before digging into details, first, we must look at the basic definition and the history of AVs.

2. The basic definition and a brief history of AVs

2.1 The basic definition of AV

AVs can be defined as the (self-driving) cars and trucks that combine sensors and software to control the vehicle safely without human drivers [7]. This definition mostly defines **fully** autonomous vehicles, which are not present now. However, there is a generally accepted road map and classification for autonomous cars prepared by the Society of Automotive Engineers (SAE) that will take humanity to a fully autonomous cars' era. The classification consists of six categories to define the developmental level of autonomous vehicles ranging from Level 0 to Level 5 [8]. **Figure 1** presents these classifications below.

2.2 The brief history of AVs

It is hard to find a starting point for the evolution of AVs. Encyclopedia Britannica suggests that AVs have taken place in science fiction works written by authors such as Isaac Asimov and Ray Bradbury [9]. It is also claimed that the time of the emergence of AVs on earth is the 1920s, and radio- or wire-controlled cars are examples of them. Isaac Asimov's short story "Sally" features autonomous cars that contain positronic brains and do not require human drivers [10]. The cars in this sci-fi example satisfy the basic definition provided in this section; however, it is hard to say that radio- or wire-controlled cars are the prototypes or precedents of

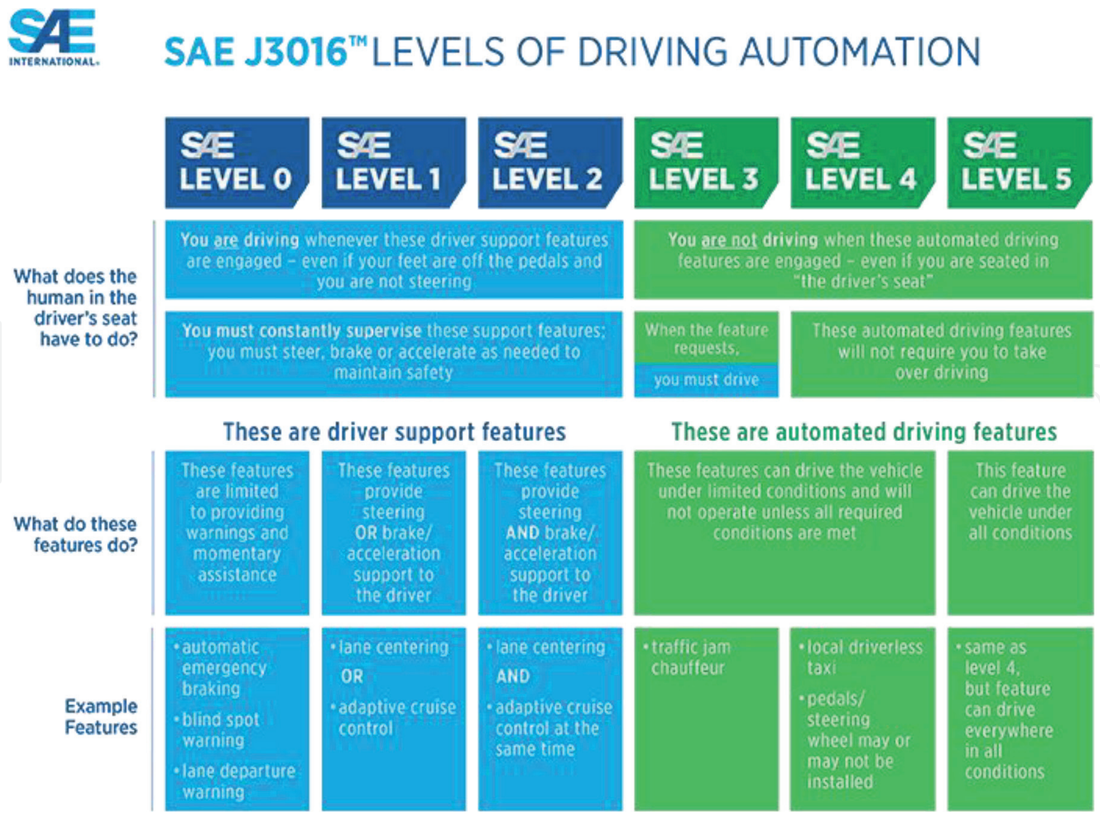

Figure 1.
Levels of autonomy (courtesy of SAE international).

today's AVs because they are directly controlled by humans, and this situation does not comply with the definition.

Modern (and capable) AVs can be said to show up through the challenges that were held by the United States (US) Defense Advanced Research Projects Agency (DARPA). In 2004, DARPA launched its first grand challenge to speed up the invention of the first fully autonomous ground vehicles. On the first grand challenge, 15 participant teams were asked to send their AVs from Barstow, California to Primm, Nevada (a 142-mile course in dessert terrain) on March 13, 2004 [11]. However, none of the AVs completed the route, and Carnegie Mellon University's Red Team's AV "Sandstorm" was the car that took the farthest distance, only 7.4 miles. Hence, the prize of $1 million went to none of the participants [12].

Eighteen months later, DARPA held its second grand challenge in the fall of 2005 with a prize of $2 million. At this challenge, 5 AVs of 195 were able to complete a 132-mile route in southern Nevada. Stanford University's AV "Stanley" won the challenge with a time of 6 hours and 53 minutes [13].

This second grand challenge proved that it is possible to make an AV that can drive itself in a demanding territory. The next step was to have AVs that can operate on the streets of a city. In 2007, DARPA conducted its third challenge under the name of "Urban Challenge." This time, AVs are asked to drive through the streets of Victorville, California on November 1, 2007, and Tartan Racing's Boss completed the race and won the prize of $2 million [14].

Besides the places they took, there were two factors that made Urban Challenge different from the previous two Grand Challenges. Urban Challenge required the participating teams to satisfy two primary necessities. The first one was to follow the California driving rules, and the second one was to succeed in the National Qualification Event (NQE) [14].

It was apparent that the participants were supposed to follow the traffic rules. Besides, it was also noteworthy that referees gave extra points to AVs if they followed the rules. For instance, though Stanford University's "Junior" completed the route 1 minute earlier than Tartan Racing's "Boss"; however, the latter was announced as the winner since it earned extra points for obeying the traffic rules [14].

Another important part of the necessities to be satisfied was the NQE. Consisting of three parts, NQE was held before the Urban Challenge to be sure that AVs were safe enough to self-drive through the streets of Victorville. The first part of the NQE, NQE A, required AVs to merge into and out of two-way jammed traffic. NQE B tested the AVs' ability to stay within a lane in an environment with obstacles and finally find an assigned place for parking. During NQE C, AVs were tested for their abilities of intersection behaviors, U-turn, and road re-planning. As a result of overall NQE, 11 of 35 AVs were selected to attend Urban Challenge [14]. It can be said that setting requirements such as following traffic rules and satisfying NQE are the milestones for AV regulations today.

3. How AVs work

An AV uses several systems to replace a human driver and drive itself. Analogous to human body, a digital brain is necessary to manage all processes needed to drive a car. Gathering data from several sources such as radio detection and ranging (RADAR),[1] sound navigation and ranging (SONAR),[2] light detection and ranging (LIDAR)[3] devices and cameras; employing computer vision to gather data and then processing those data; sending commands to mechanical parts to move AV such as making turns or stopping, and doing all these itself require an advanced computer program. Self-learning and self-acting capabilities cause these programs to be named as artificial intelligence (AI). So, what is AI?

AI, one of the most popular phenomena of the last few years, is defined as "a branch of computer science dealing with the simulation of intelligent behavior in computers" and "the capability of a machine to imitate intelligent human behavior" [15]. Similarly, as intelligent agents, AVs are also expected to imitate human drivers' behaviors. Typically, in addition to a conventional vehicle, an AV has sensors to see its surrounding environment, complex CNN[4] or DNN[5] type (or similar) algorithms to analyze the data gathered, a powerful processor to make decisions, and other parts to convert the decisions to necessary actions.

While working, an AV senses and sees every detail around itself. A traffic sign, a pedestrian on a sidewalk, a traffic light, other cars passing by, buildings surrounding horizon, and even a street animal jumping into the road must be analyzed with the AI of AV to prevent any unwanted consequences.

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[1] RADAR is a device or system consisting usually of a synchronized radio transmitter and receiver that emits radio waves and processes their reflections for display and is used especially for detecting and locating objects (such as aircraft) or surface features (as of a planet).

[2] SONAR is a method or device for detecting and locating objects especially underwater by means of sound waves sent out to be reflected by the objects.

[3] LIDAR is a device that is similar in operation to radar but emits pulsed laser light instead of microwaves.

[4] Convolutional Neural Network (CNN): a specific type of artificial neural network that uses perceptrons, a machine learning unit algorithm, for supervised learning, to analyze data. CNNs apply to image processing, natural language processing, and other kinds of cognitive tasks.

[5] Deep Neural Network (DNN): a neural network with a certain level of complexity and a neural network with more than two layers. Deep neural networks use sophisticated mathematical modeling to process data in complex ways.

The second main part of an AV is its sensors. These sensors, as mentioned above, include mostly radars, lidars, sonars, and cameras. A radar is a device that transmits radio signals, receives them back and calculate the differences between those signals to detect objects, their sizes, velocities, and distances. Depending on its purpose and the platform it is used, a radar uses the signals at different wavelengths. A sonar works in the same manner; however, it employs sound waves (a specific subset of radio waves). A lidar, on the other hand, sends and receives millions of light beams. These systems have comparative advantages and disadvantages over each other, and AVs use them together to close any safety gap.

In terms of range, radar has the advantage over lidar, sonar, and camera. Because lidar and camera require visibility all times, sonar has a shorter working range. On the other hand, since an AV is mostly interested in its close circumference, lidar is the most advantageous one because of its speed and high frequency-high quality data gathering capability [16]. Cameras are better in image gathering, and sonars are better in close range object detection.

4. Are AVs really safe?

When it comes to reliability, all of four common sensors of AVs have security deficiencies, for example, radars and sonars could be jammed with electromagnetic waves. When these two transmit the signals, someone can use an energy source emitting (reflecting) waves in the same wavelength from a different range or a different angle. When it comes to lidar, special devices can be used to create light noise to jam lidar. The exciting part is related to cameras. The AIs of AVs use camera data for image detection and recognition with high accuracy; however, a recent study proved that simple physical elements or invisible attack patterns could be used to mislead AIs [17].

Figure 2 shows a specific example to attack by using physical elements. In this figure, a regular stop sign was attached with some black and white tapes. While these taped patterns do not create suspicion in humans, it may cause severe consequences for AVs because this stop sign in **Figure 2** is received by a CNN algorithm as a "Speed Limit 45" sign as in **Figure 3** with a probability of up to 100% [18].

Another issue regarding the safety of AVs is the possibility of being hacked. In a controlled experiment conducted in earlier July 2015, two security researchers took over the control of a Jeep Cherokee [19]. The SUV was not an AV; however, it

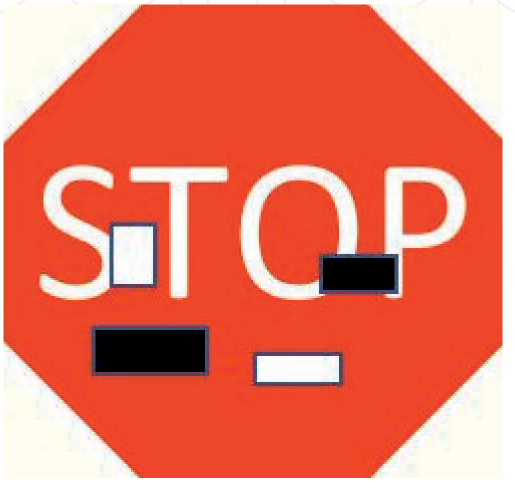

Figure 2.
A stop sign with camouflage art attack (reproduced based on figures in Table 1 of [18]).

Figure 3.
*How the stop sign in **Figure 2** is seen by AV (courtesy of https://freesvg.org/).*

connected to the internet via an interface named Uconnect that was used in thousands of automobiles. The researchers hacked the Uconnect and conducted several actions such as blowing music out from speakers, killing the engine while running, disengaging the brakes, and finally pulling over the car. Upon this incident, Fiat Chrysler Automobiles recalled 1.4 million vehicles to solve the vulnerability issues of Uconnect [20].

All these threats are considered seriously by governments, universities, researchers, and AV manufacturers. Also, as said in the third section, several different types of sensors are combined to assure safety. For instance, NHTSA follows a comprehensive and systematic approach to develop layered security and conducts research activities such as anomaly based intrusion detection or cybersecurity for update mechanisms of firmware [21].

5. The pros, cons, and moral issues of AVs

AVs are on the roads today, and they will unavoidably be a part of our lives. So, what are the pros of AVs? In other words, how can we benefit from them? Or, what are their cons; if there exist, what are the risks or dangers they will bring to our lives? There is an ongoing debate on this topic, and this section will try to clarify these questions.

5.1 The pros of AVs

5.1.1 Safety

NHTSA conducted a study for crash causation and examined accidents that occurred between July 3, 2005, and December 31, 2006 [4]. According to the study, 40.6% of the 5096 accidents were related to recognition errors such as inadequate surveillance and internal/external distraction. About 34.1% of accidents were related to decision errors such as misjudgment of other's speed, driving too fast for conditions, and false assumption of other's action; and 10.3% of accidents were related to performance errors such as panics. While using AI, supported by several sensors, it might be claimed that AVs are less prone-to-errors than humans.

Another issue with traffic accidents is the driver's general or momentary consciousness status. Being tired, driving under the influence of alcohol or any other drugs and lacking experience are the factors that may result in or contribute to an accident; however, never can be associated with an AV.

5.1.2 Economic benefits

The difference between the monetary values of a brand-new car and that of its salvaged version after a severe traffic accident is quite clear. The amount is a loss to the personal, national, and global economy. While it is expected that AVs will reduce the number of accidents, this loss will also be prevented.

As mentioned in the first chapter, each year approximately 1.35 million people die as a result of traffic accidents, and injuries related to these accidents also cost most countries approximately 1–3% of their gross domestic products [22]. Since AVs are less prone-to-errors than humans, with a decrease in the number of accidents, we may also expect a lesser loss in GDP, in other words, an increase in the net GDP.

5.1.3 Social benefits

Besides its economic burdens, traffic accidents create severe physical and emotional impacts for surrenders of accidents who became disabled. Reducing the number of accidents will prevent these consequences [23].

Another social benefit of AVs is helping the disabled, elderly, children, and other people who are in need to be transported without the help of others [24]. This help will increase the rate of disabled and older people's contribution to the workforce. Eventually, those who were carried with AVs will reach what they need, and the overall quality of life of nations will increase.

5.1.4 Environmental impacts

A new discussion is about ownership of, and beyond it, sharing AVs. For future projections, there are expected two different styles of ownership models for AVs: public service and individual owning [25]. According to the first option, an AV will be owned by a private company or a governmental agency or a municipality. The second option means that an AV will be owned by a person and become his or her private property. The owner will be able to put his or her AV into the service of others. In this way, the owner will be able to compensate for the (high) cost of his or her AV. Another study on possible energy impacts of using AVs suggests that factors such as ridesharing, less time for looking for parking can reduce fuel consumption by 90% [26], which also means lower carbon emission.

5.2 The cons of AVs

5.2.1 Software-related problems

One of the most common concerns and critics against AVs is their reliability in the context of cybersecurity. As mentioned in Section 4 of this chapter, even a conventional, non-AV car can be hacked. Just imagine your personal computers and their vulnerability against viruses, trojans, and so on. Now, think about the security updates they receive. The same protection coming with security updates will be valid for your AV; however, its infection might be fatal. On the other hand, government agencies, security experts, and car manufacturers deliberately work to prevent any hacking.

Besides being hacked, another possible thing for an AV is having software deficiencies, also known as bugs. Just like any electronic devices, AVs may have flaws, too. However, since it is developer-related and common for every product of the same model, it is easy to detect and solve those deficiencies by debugging.

5.2.2 Privacy

AVs rely on data and their processing to drive safely; however, it becomes another serious concern regarding AVs: the possible violation of personal privacy by obtaining these data illegally.

An AV will have the ability to gather and process your personal data such as how you drive, whom you travel with, where you go, how much you stay there, whom you talk to on the phone, and so on. All these data might be used to analyze your personality traits or to track you. Furthermore, if these data are obtained by a criminal organization, it can also be used for blackmailing or any other cyber-crime against you.

5.2.3 Liability

Imagine that the car you drive collides with another vehicle. You stop, get off, and walk through the other vehicle to negotiate the accident with its driver. Suddenly, you see that there is no one in the car. After getting out of the shock, you notice that you had an accident with an AV. So, what is going to happen now? Who will be responsible or how will the responsibilities be shared between the driver (if exists), manufacturer, sensor producer, or programmer? Currently, lawmakers and government authorities work on it (up to a point).

In the USA, the federal government, via NHTSA, sets the rules for new motor vehicles and their equipment. These rules are known as Federal Motor Vehicle Safety Standards (FMVSSs), and NHTSA enforces FMVSSs to ensure that manufacturers comply with them [24]. Besides, federal governments do not act to create nation-wide legislation; however, requests state governments to regulate the responsibilities [24].

In Germany, a law for AV-related liability issues was put into action on June 21, 2017 [27]. The law makes the liability be shared between the manufacturer and driver. Drivers are allowed to avert their attention from driving but not to sleep [27]. Also, the law only keeps drivers responsible for an accident unless they take control of the car within an “adequate time reserve.” Nevertheless, this undefined “adequate time reserve” is still controversial [27].

It might be claimed in advance that the responsibility issue may remain as a concern, and it will be solved in time as long as AVs and their technology level developed.

5.2.4 Environmental issues

Besides possible effects resulted from factors such as ridesharing, negative factors may result in an energy consumption increase by up to 150% [26]. As long as AVs become safer, particular speed limits might be set for them, and those limits might also be increased gradually. Also, the comfort that AVs would provide to us might cause them to be used more frequently than before. Nevertheless, higher speeds or frequent use result in more fuel consumption, which also means an increase in carbon emissions.

5.2.5 Car sharing-related health issues

A recent pandemic caused hundreds of thousands of losses of human lives. Covid-19 proved that keeping physical (social) distance between people and following hygiene rules are crucial for avoiding contagions. Since it may not be possible to be sanitized between users, there would be a risk that AVs might be responsible agents for the spread of infection. If this happens, AVs would be banned for a while. In this case, severe health or transportation problems would be inevitable.

5.2.6 Financial-infrastructure burdens on states

AVs require certain elements to ensure awareness of their surroundings, such as traffic lights, dyed lanes, and traffic signs. In many underdeveloped or developing countries, unordered traffic may be witnessed. What if an AV comes to an intersection with no traffic lights, no lanes, no signs, cars moving bumper to bumper ignoring safe distance, and drivers not yielding? How could an AV determine the right of the pass in a situation like that?

To be able to have AVs on its roads, governments will have to order the traffic in their countries. They may also have to educate their citizens. Overall, this will become a financial burden because of the increase in spending on investments in transportation infrastructure and traffic education.

5.3 Moral issues with AVs

AVs mostly rely on AI technologies. However, as mentioned above, AIs can be attacked and misled easily. A 3D printed turtle was classified as an assault rifle by Google's Inception Classifier [28].

Another issue with AI is its moral dimension. Again, assume that an AV drives an individual or a group of people from someplace to another. Suddenly, a small child or an animal that is on the edge of extinction steps onto the road. There is no such possibility for AV to stop. Its only options are hitting itself to barriers and kill the passenger(s) it carries or killing the child or the animal in front of it. What do we expect from the AV to do in this scenario? Or if a human driver is seated behind the wheel, what do we expect from him or her?

People can be kept responsible for their behaviors and the consequences of those behaviors. Hence, after an accident resulting from a human driver's fault can be handled by law enforcement and judicial authorities easily. Nevertheless, when it comes to an accident caused by an AV, the situation changes. Because instead of instincts, education level, or experience, an AV acts on its codes compiled by someone.

The codes of an AV may change with its programmer's nationality. A study published on Nature was conducted upon scenario-based AV behaviors. The researchers managed to collect 39.61 million decisions made by thousands of people from 233 countries [29]. An online platform called Moral Machine has been shared in the domain of the Massachusetts Institute of Technology (MIT). The Moral Machine reached people in 10 different languages and asked them questions related to the actions of AVs in 13 different scenarios.

With the first question, people are asked to answer what an AV should do in case of sudden brake failure at a pedestrian crossing. Omitting whom it carries, the AV is supposed to hit and kill:

- two pedestrians – a homeless person and a woman – who are violating the law by crossing on red and

- two male executives crossing the street on the green abiding by the law.

Upon completing the questions, people are also given an option to enter their demographic data. In the end, results are shared, and people can have a chance to compare their standings to the general average of others.

Some of the findings of the study are as follows:

- **Globally;** humans, more lives, and younger people are preferred to pets, single life, and older people, respectively and

- **Culturally;** when people are clustered by their geographic and cultural proximity, people from

    - **Western countries** [North American and European (protestant, catholic, and orthodox Christian)] give higher importance to humans over the pets more lives over the single life, young over old, and fit over less fit;

    - **Eastern countries** [Confucianist (i.e., Japan and Taiwan) and Islamist (i.e., Indonesia, Pakistan, and Saudi Arabia)] give higher importance to pedestrian over (AV) passenger, humans over the pet, and law-abiding over law-violating; and

    - **Southern countries** (France, French-influenced, and Latin American) give higher priority to females over males, fit over less fit, higher status over lower status, young over old, and more lives over the single life.

These findings may lead us to ask this question: Should these types of differences and concerns be taken into account by manufacturers? Barbara Wege from Audi implies the importance of this type of studies [30]. From the legislative perspective, the first ethical guideline regulating AVs was published by the Ethics Commission of Germany's Federal Ministry of Transport and Digital Infrastructure in 2017 [30]. This guideline brings some regulations on decisions that would be made by AVs in future. Article 7 under the section titled "Ethical rules for automated and connected vehicular traffic" of this report is an example of this topic [31]:

> *"... within the constraints of what is technologically feasible, the systems must be programmed to accept damage to animals or property in a conflict if this means that personal injury can be prevented."*

From the perspective of potential buyers, the results of a study on the social dilemma of autonomous vehicles prove the complexity of the topic: People prefer AVs to be programmed to sacrifice its passengers for the greater good. The same people would like other people to buy these AVs; however, they also prefer to buy an AV that protects its passengers at all cost [32].

6. Legal concerns

AVs are supposed to decrease the number of accidents and improve safety for people. However, accidents involving AVs happen, and some of them even be fatal. While in some cases those accidents have been alleged to stem from human errors, questions arise for the safety of AVs and eyes turn to government authorities to see how they regulate AV testing and deployment procedures.

A study published on Transport Reviews by Taeihagh and Lim provides a detailed analysis of how selected states regulate the main issues related to AVs: safety, liability, privacy, cybersecurity, and industrial risks [33]. The study also groups the strategies implemented by states chosen into five groups, as well:

- **No-response;** due to the uncertainty of the situation, policymakers do not take any action.

- **Prevention-oriented;** policymakers set preventive regulations to avoid risks.

- **Control-oriented;** the existence of risks is allowed; however, necessary steps are taken to control it.

- **Toleration-oriented;** policymakers clarify the steps to be taken in case of realization of risks.

- **Adaptation-oriented;** policymakers seek opinions to adopt regulations based on common sense.

Selected states are then categorized by their strategy implementations on four domains of safety, liability, privacy, and cybersecurity [33]. On the other hand, in Section 5 of this chapter, it was mentioned that the respondents of the Moral Machine survey were clustered under three different groups according to their geographical and cultural proximity: western, eastern, and southern countries. So, are there any relationships between the selected countries' AV strategies and their citizens' moral preferences?

To answer that question, first, the strategy implementation categories in [33] are reordered to represent the magnitude of their risk aversion (for human life losses) as follows:

0: Toleration/no response; **1:** Adaptation; **2:** Light control; **3:** Control; **4:** Prevention.

These numbers (or averages) are assigned to states to obtain their policy points. Then, the same states are assigned numerical values to obtain their moral value points, according to the answers their citizens provided in moral machine study. States are given two points each if their citizens give priority to humans over pet and more lives over single life. The results are shown in **Figure 4**.

Figure 4 shows a comparison of policy points of states and moral value points of their citizens. It was prepared by a primary data visualization method in the absence of enough data for further statistical analyses. However, the figure still

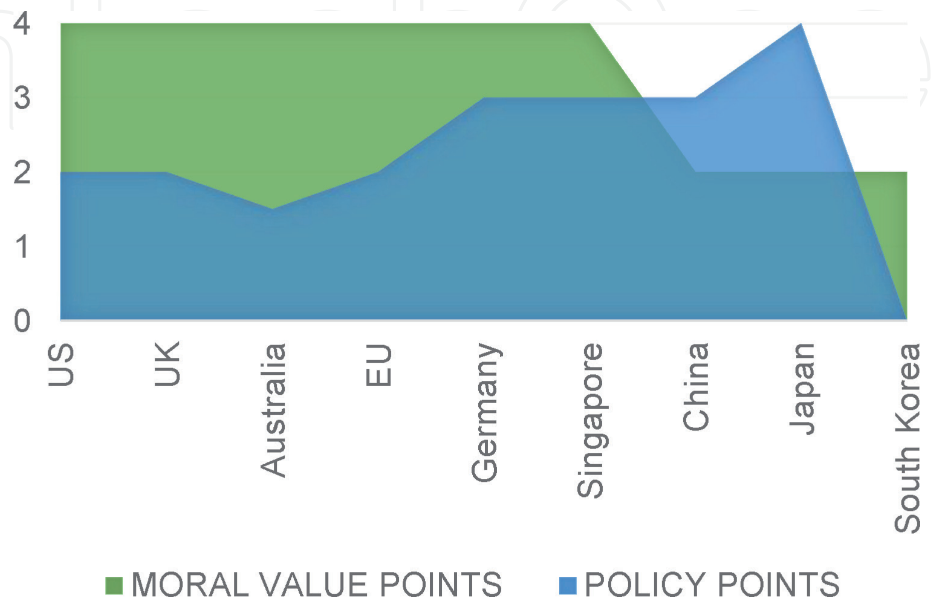

Figure 4.
Comparison of moral value and policy points.

helps us compare states' preferences on policymaking and their citizens' moral values, to an extent. For instance, people in the USA and the UK give higher priority to humans over pet and more lives over single life and get four moral value points, while the governments of both the USA and the UK implement light control strategies and get two policy points.

This situation may be explained by the governments' focus on innovation rather than safety. Elaine L. Chao, Secretary of the US Department of Transportation, touched upon this by saying "The U.S. Department of Transportation has a role to play in building and shaping this future by developing a regulatory framework that encourages, rather than hampers, the safe development, testing and deployment of automated vehicle technology" [24]. Similarly, Claire Perry, O'Neill, the former Parliamentary Under-Secretary of Department for Transport, claimed that "This review concludes that our legal and regulatory framework is not a barrier to the testing of automated vehicles on public roads … I believe we have one of the most welcoming regulatory environments for the development of this technology anywhere in the world" [34].

Contrary to the USA and the UK, Japan and China have lower moral value points than policy points. It can be explained with two views. First, from the moral value perspective, it might be suggested that these states have eastern cultures, and while they give higher importance to people over the pet, they do not give importance to more lives over single life [29]. Second, from the policymaking perspective, Japan, among the states of concern in **Figure 4**, is the most conservative state. The AV test procedures of Japan prove it. In accordance with Japan's drafted regulations, to test an AV in Japan, a driver with license must be seated, police approval and even a police officer in AV must exist, clear markings must be placed on AV, and driver must be ready to brake anytime [35].

China's situation is different from other countries. It applies preventive and light-control-oriented policies together [33]. While aiming to become a world leader in electrical and autonomous vehicle market [36], and to be able to compete with the USA, China implements low-control policies [33]. On the other hand, when it comes to allowing AVs to be tested on public roads, China sets preventive measures [33].

South Korea, one of the major car exporters, is categorized as an eastern state; however, it acts differently from all selected states by not regulating safety issues. Nevertheless, it created a council to ensure the harmony between its ministries [33]. Since there are not any international standards which are agreed on, South Korean government is waiting for it to be realized in order to set its own standards, which will be harmonized with international standards [33].

7. Conclusion

Today, thousands of AVs are on roads. Besides, that number is anticipated to climb up, and AVs are expected to constitute 25% of cars worldwide in 2035 [37]. This chapter tried to find an answer to the question of whether AVs prevent traffic accidents. After providing information about the history, general description, and working process of the AVs, their pros, cons, and moral perspectives have been presented. It might easily be suggested that AVs are more advantageous than human drivers in certain areas: an AV is better in obtaining and maintaining situational awareness. It never feels fatigued, gets tired, and works under the influence of alcohol. Because of these advantages, we may expect that AVs to reduce the number of accidents. In addition to their possible contribution to accident prevention, we will also enjoy their economic and social benefits and positive environmental impacts.

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On the other hand, AVs have several disadvantages, too. For instance, they might have software problems, or they could be hacked. Overall, as Nidhi Kalra spoke in her testimony in the US Senate, in 2016, "there is no proven, feasible way to determine autonomous vehicle safety" [38].

Today, there is not a global consensus on the safety level of the AVs. Aside from a global level, even at a national level, it is hard to find common ground. As shown in Section 6, expectations from AVs' safety levels differ from country to country, but there are even gaps between the government policies and the expectations of their citizens. However, as long as AVs are tested, and the test data are shared, processed, and used for improvisation globally, AVs will be more likely to be developed and their possibility to prevent accidents will rise.

Thanks

Endless thanks and loves to my eternal love Serap, my lion son Görkem Dennis, and my little princess Kumsal Deniz.

Also, I remember the late Turkish academician Ord.Prof.Dr. Cahit Arf with gratitude for his contributions to Mathematics and his efforts to enlighten our society by explaining how a machine could think in a public conference in 1959, as well [39].

Abbreviations

AI	artificial intelligence
AV	autonomous vehicle
CNN	convolutional neural network
DARPA	defense advanced research projects agency
DNN	deep neural network
EU	European Union
FMVSSs	federal motor vehicle safety standards
MIT	Massachusetts Institute of Technology
NHTSA	national highway traffic safety administration
NQE	national qualification event
LIDAR	light detection and ranging
RADAR	radio detection and ranging
SAE	society of automotive engineers
SDC	self-driving car
SONAR	sound navigation and ranging
UGV	unmanned ground vehicle
UK	United Kingdom
US	United States

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